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Knee Effusion

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Continuing Education Activity

The knee joint is a complex structure comprised of bones, ligaments, tendons, cartilage, and synovial fluid, all of which play integral roles in its function. A knee effusion refers to an abnormal fluid accumulation within the knee joint. Knee effusions can arise from traumatic injuries, such as ligament tears or fractures, inflammatory conditions like arthritis, infectious processes such as septic arthritis, or degenerative changes such as osteoarthritis. Factors like age, activity level, and systemic health conditions may influence the presentation and management of knee effusions. Therefore, a comprehensive evaluation considering structural changes, potential causes, and patient factors is essential for optimizing care for individuals with knee effusions.

This activity is designed to develop learners' proficiency in evaluating and managing knee effusions. Participants gain valuable insights into the condition's possible etiologies, appropriate diagnostic modalities, and evidence-based interventions, allowing them to collaborate effectively within an interprofessional team caring for patients with knee effusions.

Objectives:

- Identify the signs and symptoms suggestive of a knee effusion.
- Determine a clinically guided diagnostic workup for a patient with a possible knee effusion.
- Develop a personalized management strategy for a patient diagnosed with a knee effusion.
- Enhance communication and collaboration within an interprofessional team caring for patients with knee effusions to formulate holistic short- and long-term management plans and improve outcomes.

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Introduction

The knee is a hinge joint, one of the most frequently injured joints in the body. This joint contains multiple bursae or saclike structures containing synovial fluid. The bursae are located between the skin and bony prominences. Some of these bursae communicate with the knee joint. Fluid accumulation in a joint's intraarticular space and bursae is called an "effusion."

Knee effusions can occur at any age. The condition often presents with knee swelling, pain, stiffness, and limited range of motion. Knee effusions arise from various causes. Proper diagnosis and management typically involve identifying the effusion's underlying cause through clinical evaluation, imaging studies, and possibly joint fluid analysis. Treatment may include rest, ice, elevation, anti-inflammatory medications, physical therapy, and, in some cases, knee fluid drainage.[1]

Etiology

The etiology of a knee effusion may vary from acute trauma and infection to chronic systemic conditions, including degenerative, hematologic, rheumatologic, vasculitic, and oncological conditions.[2]

Minor, asymptomatic effusions can occur in healthy individuals. More significant joint effusions indicate pathology. Large effusions can give rise to cysts within the popliteal fossa. A knee effusion can consist of synovial fluid or hemarthrosis and is classified as traumatic or nontraumatic. Knee joint hemarthrosis' primary mechanism is forced rotation of the loaded joint.[3]

Hemarthrosis' articular cartilage complications are similar across different age groups, but the etiology varies. In adults, traumatic hemarthrosis may be due to anterior cruciate ligament ruptures (70%), patellar dislocation (15%), meniscal tears (10%), osteochondral fragment fractures (5%), and miscellaneous injuries (5%).[4][5][6] Patellar dislocation was reported to be the most common etiology of traumatic hemarthrosis in adolescent age groups.[7][8]

Epidemiology

Knee injuries represent over half a million emergency department visits in the United States.[9][10] The knee is more frequently injured than other joints because it is part of a weight-bearing limb and has less joint congruity than the hip and ankle.[11]

The lifetime prevalence of knee swelling has been reported to be as high as 27%.[12] Knee effusions in children most commonly affect infants and teenagers. Pediatric knee effusion with hemarthrosis usually arises from a sports-related traumatic knee event.

Pathophysiology

A knee effusion may arise from an acute or chronic, inflammatory or noninflammatory, traumatic or atraumatic condition. The most common diagnoses in the primary care setting are osteoarthritis, trauma, and gout.[13] A knee hemarthrosis increases the intracapsular pressure, leading to pain and reduced knee joint range of motion mainly due to reflex quadriceps muscle firing inhibition.[14] The risk of developing osteoarthritis from longstanding knee hemarthrosis increases regardless of etiology. Blood and other inflammatory mediators released into the joint initiate the pathological process of chondral injury. Complex biochemical interactions between various metabolites and proinflammatory mediators culminate in irreversible articular cartilage damage and joint degeneration as long-term sequelae.[15][16]

Histopathology

Normally, synovial fluid hyaluronic acid prevents friction and lubricates the knee joint. Synovial fluid has antibacterial properties that help maintain a sterile environment within the joint. However, synovial microscopic examination of knee joint effusion reveals abnormal changes. Knee joint effusion consists of synovial fluid and blood plasma ultrafiltrate and includes hyaluronic acid, glycoproteins, lubricin, proteinases, and collagenases. Inflamed synovium contains large clefts, allowing molecules of almost any size to pass through its membrane and cause an effusion. Synovial fluid also contains substances identical to plasma proteins.

History and Physical

History

Evaluating an acutely swollen knee begins with a thorough history and examination of the affected and contralateral knees. Essential information to elicit include the injury mechanism, onset acuity, symptom duration, previous history of the ailing joint, aggravating symptoms, and associated systemic manifestations. A knee effusion with a recent traumatic history may suggest an internal derangement such as a ligament or meniscal tear. In contrast, an atraumatic effusion is highly suspicious for infection or systemic disease. A history of previous surgery should be determined in every patient with knee swelling. Patients may complain of swelling and stiffness with decreased range of motion. A large effusion can cause the inability to completely extend the knee. The patient may keep the knee at 15° of flexion when at rest.

Red flags

Red flags include fever, non-weight bearing, loss of distal pulses and sensation distal to the knee, open fractures, and cellulitis overlying the knee. These red flags typically indicate immediate evaluation. The affected knee should always be compared with the unaffected knee. In septic arthritis, joint pain, a history of joint swelling, and fever are present in over 50% of cases.[17]

Physical Examination

Physical examination should focus on finding signs that can help determine the knee effusion's etiology. Comparing the contralateral knee is mandatory and always helpful in spotting abnormalities (see **Image**. Knee Effusion).

Inspection

The absence of dimples is the first sign of effusion and may be easily noted when comparing the affected knee to the contralateral one. Patellar swelling and suprapatellar bursal distention may be found in more significant effusions. Deformities and dislocations are noticeable in most scenarios. Skin evaluation for color changes, such as erythema, may indicate underlying sepsis. The presence of a rash could direct the physician to further investigate for systemic disorders, particularly rheumatologic, hematologic, and vasculitic conditions. The patient's gait and lower limb alignment should also be evaluated. Malalignment accompanying chronic conditions may indicate the effusion's underlying etiology.

Palpation

The bony and soft tissue landmarks and the joint line should be gently palpated. Joint-line tenderness could indicate meniscal pathology. Tenderness over a tendon or ligamentous insertion could indicate tendonitis or apophysitis. Tenderness over the femoral condyles' articular surfaces may indicate osteochondritis dissecans. A subjective joint pain with no objective tenderness over bony or soft tissue structures most likely points toward arthralgia.

Range of motion assessment

Patients may have a restricted range of motion and pain with ambulation. Excess fluid can cause pressure and irritation within the joint, contributing to pain and discomfort during weight-bearing activities like walking.

Special tests

The balloon, ballottement, and bulge tests can help confirm knee effusion. The balloon test is performed by compressing the suprapatellar pouch against the femur with the thumb and fingers, making the effusion more appreciable. The ballottement test is performed as a continuation of the balloon test by pressing the raised patella downward against the femur. A gentle patellar tap and float should be appreciated. The bulge test is performed when only minimal effusion is apparent on inspection. The effusion may be appreciated by milking all the fluid laterally and pressing it until it forms a medial bulge.

The following special tests may be performed if suspecting specific injuries:

- McMurray and Thessaly tests for medial and lateral meniscus tears
- Lachman and anterior drawer tests for an anterior cruciate ligament tear
- Posterior drawer test for posterior cruciate ligament tear
- Varus and valgus stress tests for lateral and medial collateral ligament injuries, respectively
- Patellofemoral joint compression test for patellofemoral compartment pathology [18]

Neurovascular assessment

Knee effusions may cause arterial flow reduction and nerve compression, warranting immediate intervention. The following structures may be compromised by mass effects arising from a knee effusion:

- Popliteal artery, affecting downstream vessels like the anterior and posterior tibial arteries and dorsalis pedis
- Peroneal nerve

- Posterior tibial nerve

Lower-limb arterial flow may be assessed by palpation. Posterior tibial nerve function may be examined by ankle plantar flexion. The superficial peroneal nerve's function may be evaluated by ankle eversion. Great-toe extension strength testing can help test deep peroneal nerve function. Lower limb sensory tests must also be completed.

Evaluation

Imaging

Weight-bearing radiographs in 3 planes—anteroposterior, lateral, and axial—are indicated in patients presenting with an acutely swollen knee. Radiography helps evaluate for a fracture, especially if a history of trauma has been elicited. Plain x-rays can also detect rheumatoid arthritis-related erosive disease. Joint space narrowing may be found in patients with osteoarthritis and rheumatoid arthritis.[19]

A fabella—a sesamoid bone in the gastrocnemius lateral head tendon—may be seen in some individuals' lateral knee x-rays. This structure can serve as a radioopaque marker for the knee synovium's posterior border. The fabella sign (fabella displacement) is seen in the presence of a synovial effusion and a popliteal mass. Increased suprapatellar bursal opacity and widening may also be evident on lateral knee radiographs showing the fabella sign.

An ultrasound can help differentiate between complicated and simple effusions. This modality may also be used to guide arthrocentesis.

Knee arthroscopy is the gold standard diagnostic modality for evaluating and managing intraarticular knee pathologies. Clinical examination or magnetic resonance imaging scans are not 100% sensitive in excluding intraarticular pathologies.

Synovial Fluid Aspirate Analysis

Arthrocentesis and subsequent synovial fluid analysis should be done in all cases of unexplained knee effusion. The aspirated fluid should be analyzed for cell counts, gram staining, bacterial cultures, and crystal analysis.

The following should be included in the synovial fluid aspirate analysis report:

- Complete cell count with differential (white blood cell or WBC, polymorphonuclear or PMN leukocytes)
- Crystal examination
- Bacterial culture and gram staining
- Viscosity
- Glucose

Hemarthrosis is commonly caused by joint trauma. Polarized microscopy can detect fat droplets, indicating an articular fracture. Other clotting disorders like hemophilia can cause hemarthrosis in the absence of trauma.

The presence of crystals cannot exclude septic arthritis with certainty. Septic arthritis can occur concurrently with gout or pseudogout in less than 5% of cases. Meanwhile, a low synovial fluid glucose level suggests joint infection. Still, low glucose levels are present in only about 50% of patients with septic joints. Rheumatoid arthritis may also have low synovial fluid glucose. The fasting glucose levels in synovial fluid obtained from joint effusions are typically less than half of the glucose levels simultaneously measured in the blood. In rheumatoid arthritis, expect decreased viscosity and poor mucin clot formation.[20]

Septic arthritis

Septic arthritis produces a characteristic combination of synovial fluid aspirate analysis findings. Joint fluid often appears cloudy or purulent. A cell count with WBCs of more than 50,000 cells/mm^3 is considered diagnostic for septic arthritis. However, lower counts do not rule out a joint infection.[21] A prosthetic joint with WBCs greater than 1,100 cells/μL is considered septic. Gram stains only identify infective organisms a third of the time. Glucose will be less than 50% of the serum level.

Noninflammatory synovial fluid

Noninflammatory synovial fluid usually contains less than 60 to 180 cells per mL, most of which are mononuclear. Synovial fluid is considered noninflammatory if it contains less than 2000 cells/mL, but most synovial fluid samples from patients with osteoarthritis contain less than 500 cells per mL.

The most common cause of noninflammatory knee effusions of the knee, with synovial fluid WBC count typically less than 2000 cells/mL, is osteoarthritis. Other causes include osteonecrosis, Charcot arthropathy, sarcoidosis, amyloidosis, hypothyroidism, and acromegaly. Inflammatory arthritis, with synovial fluid WBCs greater than 2000 cells/mL, may arise from infection, autoimmune disease, and crystal-induced arthritis. Aspiration of dark brown serosanguinous fluid should raise the possibility of pigmented villonodular synovitis.

Inflammatory synovial fluid

Various conditions present with synovial fluid WBC count greater than 2,000 leukocytes/mL. These clinical entities may be distinguished based on leukocytosis severity and differential count. Trauma often manifests with less than 5000 WBCS/mL. RBCs may also be seen if bleeding occurs in the joint. Toxic synovitis usually has 5,000 to 15,000/mL and less than 25% PMNs. Acute rheumatic fever often has 10,000 to 15,000 and 50% PMNs. Juvenile rheumatoid arthritis and various other autoimmune conditions usually have 15,000 to 80,000 and 75% PMNs.

Infectious arthritis usually causes the most intense synovial fluid leukocytosis, with cell counts of 50,000 to 200,000 cells/mL containing over 90% PMNs. Lower leukocyte counts in suspected infectious cases are common in early bacterial arthritis and disseminated gonococcal infection.

Noninfectious conditions like gout, pseudogout, acute rheumatic fever, reactive arthritis, and rheumatoid arthritis can produce a markedly inflammatory synovial effusion. A finding of greater than 90% PMNs despite a relatively low total leukocyte count should prompt concern for infection or crystal-induced disease. However, the presence of crystals cannot exclude septic arthritis with certainty.[22] A finding of WBCs greater than 50,000/mm^3 in the setting of trauma suggests infectious arthritis.

Septic arthritis typically has 80,000 to 200,000 cells/mL and greater than 75% PMNs on synovial fluid aspirate analysis. Synovial fluid WBC count and percentage of PMN cells from arthrocentesis are the most significant predictors of septic arthritis. The likelihood ratio increases as the synovial fluid WBC count increases.

Counts greater than 50,000/μL have a likelihood ratio of 7.7 (95% confidence interval, 5.7-11.0). Counts greater than 100,000/μL have a likelihood ratio of 28.0 (95% confidence interval, 12.0-66.0). Finding a PMN cell count of at least 90% on the same synovial fluid sample suggests septic arthritis with a likelihood ratio of 3.4 (95% confidence interval, 2.8-4.2), while a PMN cell count of less than 90% lowers the likelihood ratio to 0.34 (95% confidence interval, 0.25-0.47).

Other Labs

Blood tests that can help determine the etiology of knee effusion include the following:

- Lyme titers, especially in the pediatric population with atraumatic unilateral knee effusion [23]
- Antistreptolysin-O for poststreptococcal infection [24]
- Rapid plasma reagin for syphilis
- Elevated WBC in a complete blood count (CBC) for osteomyelitis, inflammation, or malignancy
- Inflammatory markers, including C-reactive protein and sedimentation rate
- Antinuclear antibody for possible autoimmune disorders

Urine studies help determine the presence of urinary tract infections and sexually transmitted diseases, including gonorrhea, chlamydia, and trichomonas, which can cause reactive arthritis. Polymerase chain reaction tests of affected mucosal sites should also be considered if suspecting gonorrhea and chlamydia. Stool cultures can detect salmonella, yersinia, campylobacter, and shigella, which can all cause reactive arthritis.[25]

A saline load test may be utilized to determine if a nearby wound communicates with the knee joint. The test requires injecting 155 mL of normal saline in the knee to reach 95% sensitivity.

Treatment / Management

Pain Control

Acute pain and swelling warrant individualized treatment. Options include splints, cold or ice packs, partial or non-weight-bearing braces, and analgesics like nonsteroidal anti-inflammatory drugs (NSAIDs). Drainage may be effective if the joint has significant effusion causing pain. If suspecting an infection, the fluid sample should be obtained, tested, and cultured before starting antibiotics. Intraarticular steroids should be avoided until infection or other contraindications are first ruled out.

Septic Joint Treatment

Intravenous antibiotics should be initiated for suspected infection after sending joint fluid specimens for analysis. The most common bacterial agents causing septic arthritis include staphylococci (40%), streptococci (28%), gram-negative bacilli (19%), mycobacteria (8%), gram-negative cocci (3%), gram-positive bacilli (1%), and anaerobes (1%). An orthopedic consult may be necessary. Joint drainage is associated with rapid recovery and low morbidity. Arthroscopy allows internal joint visualization, adhesiolysis, purulent pocket drainage, and necrotic material debridement.[26]

Managing Ligamentous Injuries

A knee brace may be placed on the affected knee as initial treatment. The patient should be given an outpatient referral to an orthopedic surgeon for definitive treatment. Complete ligamentous disruption and knee instability warrant surgical intervention.

Fractures

An orthopedic specialist determines if conservative or operative management is necessary. The Salter-Harris classification may be used for pediatric fractures involving the growth plate.

Rheumatologic conditions

NSAIDs or acetaminophen may be used for pain control. A rheumatologist prescribes the definitive treatment.

Reactive Arthritis

The primary infection should be treated with the appropriate antibiotic. NSAIDs and acetaminophen may be used for pain.

Differential Diagnosis

Knee effusion has broad differential diagnoses that include those listed below. A thorough clinical evaluation and judicious use of diagnostic studies can differentiate these conditions and guide definitive management.

- Infection
- - Bacterial
  - Mycobacterial
  - Spirochete (Lyme, syphilis)
  - Viral
- Crystal (gout and pseudogout)
- Spondyloarthritis
- - Reactive arthritis
  - Inflammatory bowel disease

- Hemarthrosis
- Acute injury
- Osteoarthritis
- Osteonecrosis
- Malignancy
- Autoimmune disorders

Prognosis

The following conditions are associated with poor outcomes in patients with knee effusion:

- Age 80 or older
- Concomitant involvement of a larger joint, ie, hip or shoulder
- Bacterial growth on synovial fluid cultures despite appropriate antibiotic therapy for 7 days
- Delay longer than 7 days before starting treatment
- Comorbidities, including diabetes mellitus, bacteremia, chronic kidney disease, and rheumatoid arthritis [27] [28]

Other factors that can impact knee effusion's prognosis include symptom severity, patient adherence, and immune status.

Complications

Delaying treatment beyond 24 hours may result in permanent joint function limitation and subchondral bone loss. Bacterial invasion can lead to permanent articular cartilage injury. Prosthetic joint infection may result from an untreated local bacterial invasion that has spread to the prosthesis hematogenously.[26]

Deterrence and Patient Education

Preventive measures aim to reduce the risk of injury, inflammation, and other factors contributing to the development of knee effusions. Patients may be educated on maintaining a healthy weight, strengthening the muscles, improving flexibility, and avoiding overuse to protect from osteoarthritis. Using the proper exercise techniques, wearing protective pads, and avoiding risky behaviors prevent traumatic knee injuries. Regular medical consultations and treatment adherence help manage chronic conditions affecting the knees. Staying well-hydrated supports knee joint lubrication and cushioning. These measures may not prevent all knee effusion cases but can help minimize the risk of developing the condition.

Pearls and Other Issues

Knee effusion typically presents with swelling, pain, stiffness, and limited range of motion in the affected knee. The swelling may be visible and feel fluid-filled or boggy upon palpation. The condition may result from various underlying causes, including trauma, infection, inflammation, and metabolic disorders. Diagnosing knee effusion involves combining clinical assessment with imaging studies and analysis of the synovial fluid obtained via arthrocentesis.

Examination of synovial fluid obtained from the affected knee can provide valuable diagnostic information. Analysis includes evaluating the fluid's appearance, cell count, differential, protein levels, glucose levels, and microbiological cultures. The management depends on the underlying cause. Treatments range from noninvasive measures such as cold compress application and NSAID intake to intraarticular injections and more invasive surgical interventions. Untreated or poorly managed knee effusion can lead to complications such as chronic inflammation, joint stiffness, cartilage damage, knee instability, and secondary osteoarthritis.

Poor prognostic indicators include advanced age, presence of concomitant large-joint injuries, treatment delay or unresponsiveness, and comorbidities. Measures that can prevent knee effusion include maintaining a healthy weight, avoiding excessive knee stress or overuse, using proper techniques during physical activity, wearing protective gear when necessary, managing underlying medical conditions, and seeking prompt medical attention for joint injuries or symptoms of inflammation.

Enhancing Healthcare Team Outcomes

Managing knee effusions requires an interprofessional team of healthcare professionals, including nurses, laboratory technologists, and clinicians in different specialties. Without proper management, morbidity and mortality from an undiagnosed knee effusion may increase.

When the triage nurse identifies an acute knee effusion, the primary care or emergency medicine physician must be notified immediately to determine whether prompt interventions are warranted, as in cases of open fractures and septic arthritis.

Orthopedic specialists may lend their expertise in managing traumatic cases. Consultation with the pharmacist and infectious disease clinician about the choice and administration of antibiotics can increase efficacy and patient safety. Rheumatologists may be involved in cases of autoimmune arthritis. If the patient requires any resources for home, the social worker and case manager should be notified. Knee pain and decreased mobility warrant the services of a physical therapist for early ambulation.

All members of the interprofessional team must exercise open communication with the rest of the care team to ensure optimal patient outcomes, alert appropriate personnel regarding changes in the patient's condition, and maintain accurate records so that everyone involved in the case has updated, precise patient information from which to make clinical decisions.

Communication among providers is critical to achieving the best result using this shared decision-making model. This interprofessional approach must use evidence-based medicine and a unique, integrated care pathway. The best prognosis and outcome depend on the early recognition of potential complications.

Review Questions

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